Powering The Nation Through Young Generation -

The Ulu Jelai and Hulu Terengganu Hydroelectric Project


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POWER AND WATER: A SUCCESSFUL COMBINATION

Tenaga Nasional Berhad had embarked on two major hydroelectric projects in Peninsular Malaysia with a combined capacity to produce 637MW of power. In managing the large projects, TNB invested in young local engineers to ensure that hydroelectric project expertise would grow and be sustainable for the future.

The two hydroelectric projects are the Hulu Terengganu Hydroelectric Project in Hulu Terengganu and Ulu Jelai Hydroelectric Project in Pahang.

HULU TERENGGANU HYDROELECTRIC PROJECT

The project is located upstream of the Kenyir Reservoir in Terengganu. The reservoir was the result of the construction of the 400MW Kenyir Hydroelectric Project in the 1980s. Figure 1 shows the location map of the Hulu Terengganu Hydroelectric Project (HTHEP).

The HTHEP has a total installed capacity of 265MW and consists of two hydro power schemes: Puah Power Scheme (2x125MW) and Tembat Power Scheme (2x7.5MW).

The Puah Power Scheme has a catchment area of 511 sq km including 101 sq km of the Tembat catchment. The annual average energy output of the Hulu Terengganu Hydroelectric Project is estimated to be 467 GWh/annum, of which 413 GWh/annum will be produced by the Puah generating units and 54 GWh/annum by the Tembat generating units.

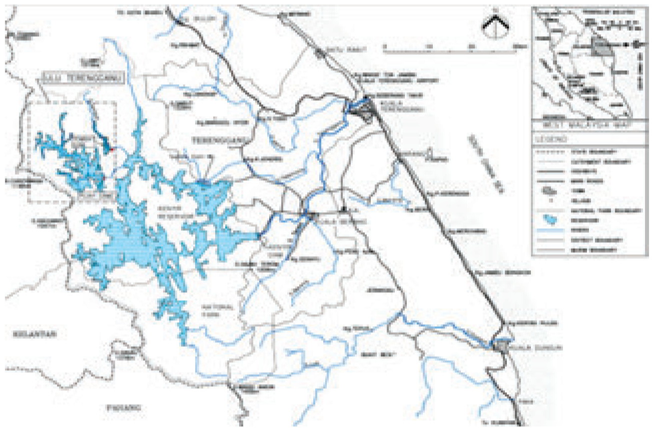

Figure 1: Location of Hulu Terengganu Hydroelectric Project

PROJECT FEATURES

The main features of the Puah Power Scheme are:

- A 79m-high earth-filled dam, gated spillway with 3 radial gates,
- Two headrace tunnels,
- Tailrace tunnels,
- Surge chamber,
- Emergency cable ventilation tunnel,
- Access tunnel,
- Tailrace tunnel,
- Intake structure,

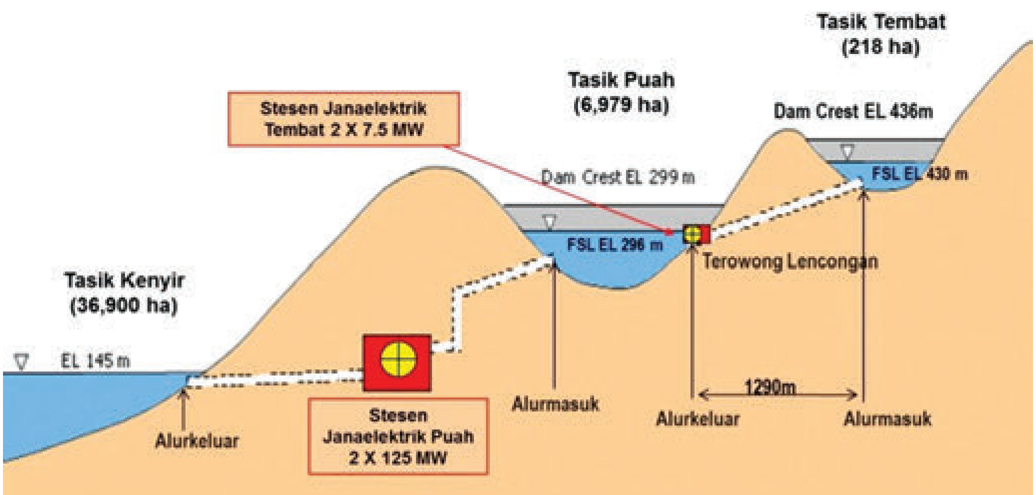

Figure 2: Cross-sectional view of the hydroelectric power scheme

- Underground powerhouse,
- Other appurtenant structures and,
- 275-kV switchyard.

At the El. 296m full supply level (FSL), the Puah Reservoir has a surface area of about 70 sq km and a gross storage of 1,735.0 × 106 cubic metres.

The main features of the Tembat Power Scheme are:

- A 36m-high concrete dam with a free overflow spillway,
- Headrace tunnel,
- Intake structure,
- Surface power house,
- Other appurtenant structures.

At the El. 430m FSL, the Tembat reservoir has a surface area of 2.2 sq km and a gross storage of 19.90×106 cubic m.

Tenaga Nasional Berhad appointed Loh & Loh Construction Sdn. Bhd. and Sinohydro Corporation Ltd Joint Venture as the contractor responsible for the main civil works, including the construction of the two dams, water transfer tunnel and underground power house. The joint venture, which comprised SNC-Lavalin Inc, SNC-Lavalin Power (Malaysia) Sdn. Bhd., KTA Tenaga Sdn. Bhd. and G&P Professionals Sdn Bhd., provided the detailed engineering design for the main civil works, engineering design review for the electrical and mechanical works, project management and site supervision. The construction work, which began in late 2010, was completed in October 2015.

ULU JELAI HYDRO ELECTRIC PROJECT (HEP)

The generating station is located on Sungai Bertam, Sungai Lemoi and Sungai Telom in the Cameron Highlands area of Pahang.

It is approximately 140km north of Kuala Lumpur and 80km from the west coast. The catchment area for Susu Dam on Sg. Bertam is approximately 158 sq km. This catchment borders with the upstream Sultan Abu Bakar Dam on the west, Sg. Telom catchment to the north and Sg. Lemoi catchment to the south. The catchment areas at the Telom and Lemoi intake sites are approximately 122 sq km and 83 sq km respectively.

The project is designed to provide peaking electrical power to the national grid and comprises of a main dam and reservoir, two inter-basin transfer schemes, an underground power station and power waterway system. The main Susu Dam is located on Sg. Bertam. The inter-basin transfer schemes abstract water from the adjacent Lemoi and Telom catchments and discharge it to the reservoir via two bored tunnels.

The Power House Chamber

Concrete work around the turbine opening

Lowering of the spiral case

A power waterway tunnel system transfers water from the reservoir to the power station and returns it to Sg. Telom approximately 4km downstream from the dam site.

The Ulu Jelai Underground Power Station (which is sometimes described as the Generating Station, Powerhouse or Generating Plant) has a generating capacity of 372MW with an average annual energy of 374GWh.

The underground power station complex, formed of caverns, tunnels and shafts, is connected to many water-conveying and open tunnels and contains the following:

- Power station (including machine, assembly and service bays),
- Transformer hall,
- IPB galleries,
- Draft tube conduit and tunnels and,
- Surge chamber and,
- Other underground facilities.

As such, the power station complex is considered one of the main engineering feats of the whole Ulu Jelai project.

Drill and blast techniques were employed for the excavation of the underground power station, transformer and surge chamber caverns.

The power station cavern itself, comprising two vertical shaft Francis Turbo Generator units, has dimensions of 82m in length, 45m in height and 24m in width.

The structures in the complex were built using conventional reinforced concrete methods. A total of 19,000 cubic metres of concrete was poured into the complex.

There are 8 floors, of which 5 are for the electro-mechanical plant and the rest for operational services and administrative purposes such as offices and control areas, amenities and ventilation system.

The power station, transformer hall and surge chamber cavern were excavated in fresh, coarse grained porphyritic (strong to very strong granite). The discontinuities had 2-3 joint sets with random. Rock classes were G1-G2.

The rock class and support classification as per an extract table.

Support Type Table - Drill and Blast and Shaft

Rockmass Unit	"Q" Range (General)	"Q" Range (Tailrace Tunnel) (Headrace Main Tunnel) (Headrace Intackeshaft) (Main Access Tunnel)	Support Type
G1↓, G1	> 6	> 10	Support Type 1
G2	2 TO 6	2 TO 10	Support Type 2
G3, WG1	0.2 TO 2	0.2 TO 2	Support Type 3
WG2	0.02 TO 0.2	0.02 TO 0.2	Support Type 4
"Residual Soil/ Completely Weathered Rock" or WG3	< 0.02	0.02	Support Type CW or WG3

The underground excavation of the main power station cavern, which comprises the Machine (Hall), Service and Assembly Bays, was carried out starting from the Main Access Tunnel (MAT) towards the Construction Adit.

Excavation started on 16 December, 2012, using drill and blast methods. The staged cavern excavations were started in an 8.30m-wide central heading in the cavern crown. This phase proceeded with full-face drill and blasting in advances some 2-4m long, as determined by space available for the drilling jumbo and the encountered rock conditions.

The two adjacent side headings proceeded with equal face advances as soon as the central heading had advanced a minimum of 18m. Special attention was given to the drilling procedures, especially as the end of some of the drilled holes were planned to form the final excavation surface of the caverns crown and walls.

Pre-splitting and smooth-blasting techniques were used at each stage as necessary to achieve the required cavern dimensions and with minimal over and under-break. The excavations were completed on 29 December, 2013.

Power Station – Waterproof Roof Membrane

There were various sets of both 15m-long extensometers placed in the crown of the caverns and convergence optical targets placed to the wall of the cavern, all progressively installed and monitored as the excavations were carried out, phase by phase.

There was a relatively small amount of groundwater inflow encountered in the caverns during the excavation. However, as precaution against future groundwater, inflows strip drains were installed to the crown of the Power House Cavern, Transformer Hall Cavern and Surge Chamber Cavern at 2m spacing underneath the shotcrete. The ends of the strip drains were connected to perimeter collector drains which discharged into the dewatering pit.

In general, the Contractor was able to achieve acceptable quality in accordance with the specifications and all non-compliances were eventually closed out. The necessary contractual framework needed to properly supervise the construction works, was in place prior to the start of construction, enabling the Engineer to manage, monitor and record the performance of the Contractor at every stage. The construction works proved to be a valuable experience for everyone involved and provided lessons in how to adopt a constructive and a teamwork approach to handling technical issues. Such an opportunity will encourage local young engineers to consider a career in tunnelling. ■

Authors' Biodata

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